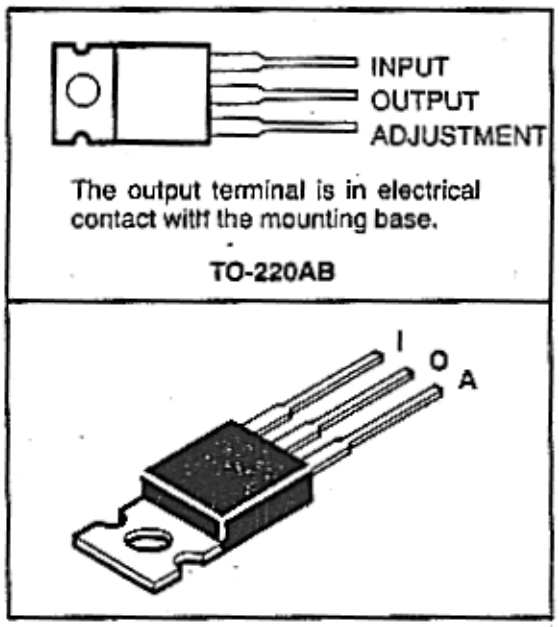
P/N 143909

TL783C
HIGH-VOLTAGE ADJUSTABLE REGULATOR

D2659, SEPTEMBER 1981–REVISED DECEMBER 1991

- **Output Adjustable From 1.25 V to 125 V, When Used With an External Resistor Divider**
- **700-mA Output Current**
- **Full Short-Circuit, Safe-Operating-Area, and Thermal Shutdown Protection**
- **0.001%/V Typical Input Regulation**
- **0.15% Typical Output Regulation**
- **76-dB Typical Ripple Rejection**
- **Standard TO-220AB Package**

KC PACKAGE
(TOP VIEW)



The output terminal is in electrical contact with the mounting base.

TO-220AB

escription

The TL783C is an adjustable 3-terminal high-voltage regulator with an output range of 1.25 V to 125 V and a DMOS output transistor capable of sourcing more than 700 mA. It is designed for use in high-voltage applications where standard bipolar regulators cannot be used. Excellent performance specifications, superior to those of most bipolar regulators, are achieved through circuit design and advanced layout techniques.

As a state-of-the-art regulator, the TL783C combines standard bipolar circuitry with high-voltage double-diffused MOS transistors on one chip to yield a device capable of withstanding voltages far higher than standard bipolar integrated circuits. Because of its lack of secondary breakdown and thermal runaway characteristics usually associated with bipolar outputs, the TL783C maintains full overload protection while operating at up to 125 V from input to output. Other features of the device include current limiting, safe-operating-area (SOA) protection, and thermal shutdown. Even if the adjustment terminal is inadvertently disconnected, the protection circuitry remains functional.

Only two external resistors are required to program the output voltage. An input bypass capacitor is necessary only when the regulator is situated far from the input filter. An output capacitor, although not required, will improve transient response and protection from instantaneous output short circuits. Excellent ripple rejection can be achieved without a bypass capacitor at the adjustment terminal.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

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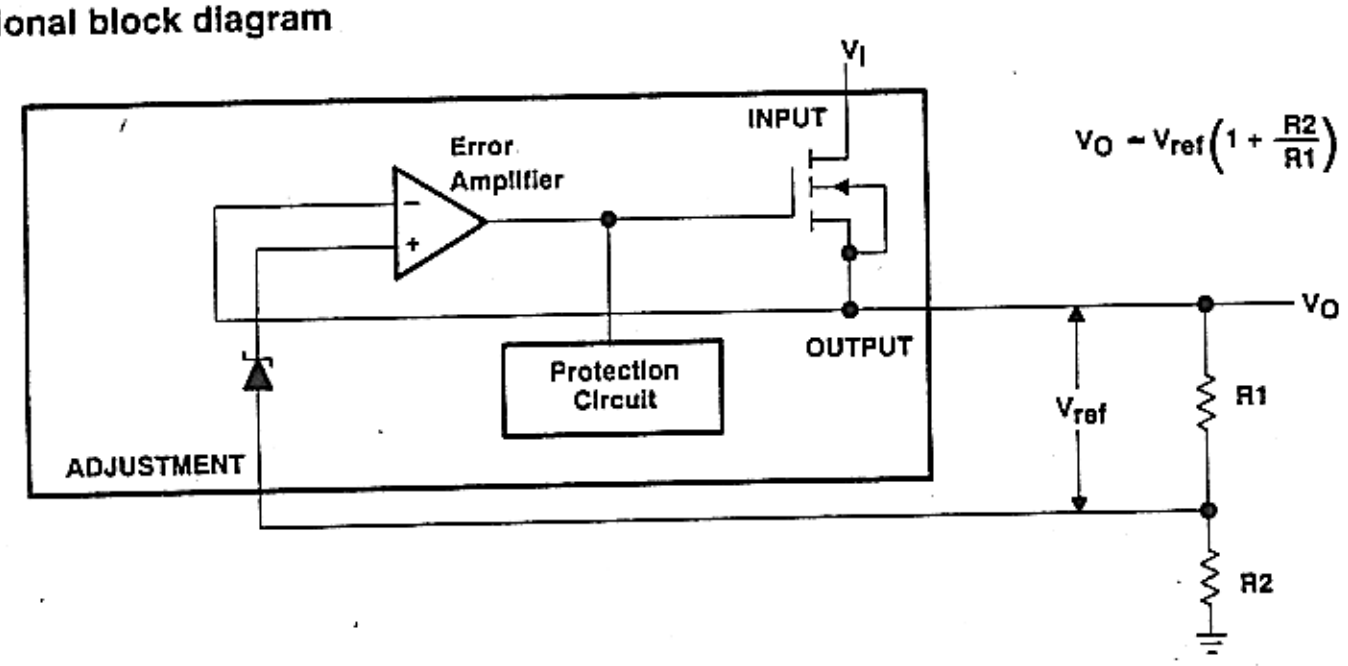
functional block diagram



absolute maximum ratings over operating temperature range (unless otherwise noted)

Input-to-output differential voltage, $V_I - V_O$	125 V
Continuous total dissipation at (or below) 25°C free-air temperature (see Note 1)	2 W
Continuous total dissipation at (or below) 70°C case temperature (see Note 1)	20 W
Operating free-air, case, or virtual junction temperature range	0°C to 150°C
Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds	260°C

NOTE 1: For operation above 25°C free-air or 70°C case temperature, refer to Figures 1 and 2, respectively. To avoid exceeding the design maximum virtual junction temperature, these ratings should not be exceeded. Due to variations in individual device electrical characteristics and thermal resistance, the built-in thermal overload protection may be activated at power levels slightly above or below the rated dissipation

FREE-AIR TEMPERATURE
DISSIPATION DERATING CURVE

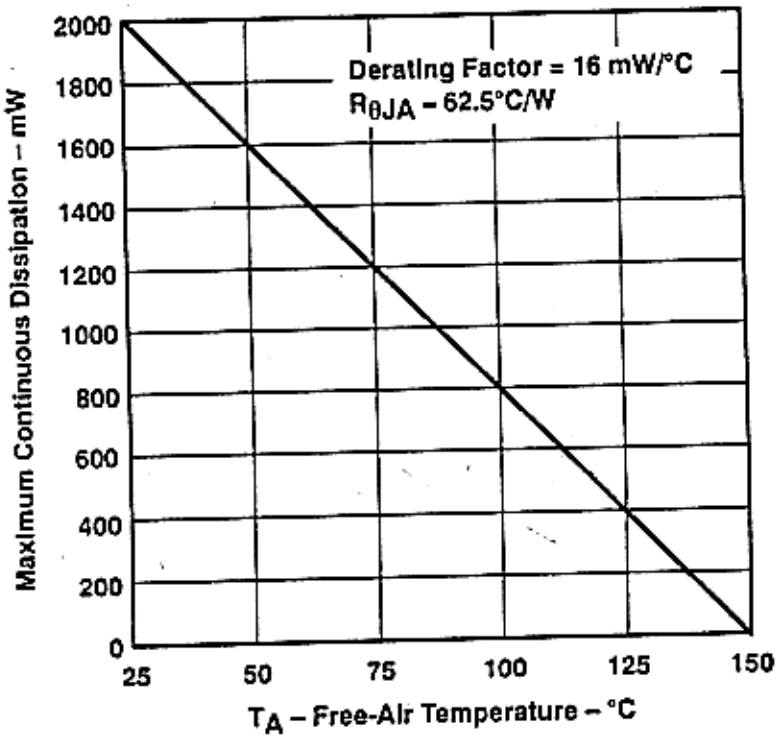


Figure 1

CASE TEMPERATURE
DISSIPATION DERATING CURVE

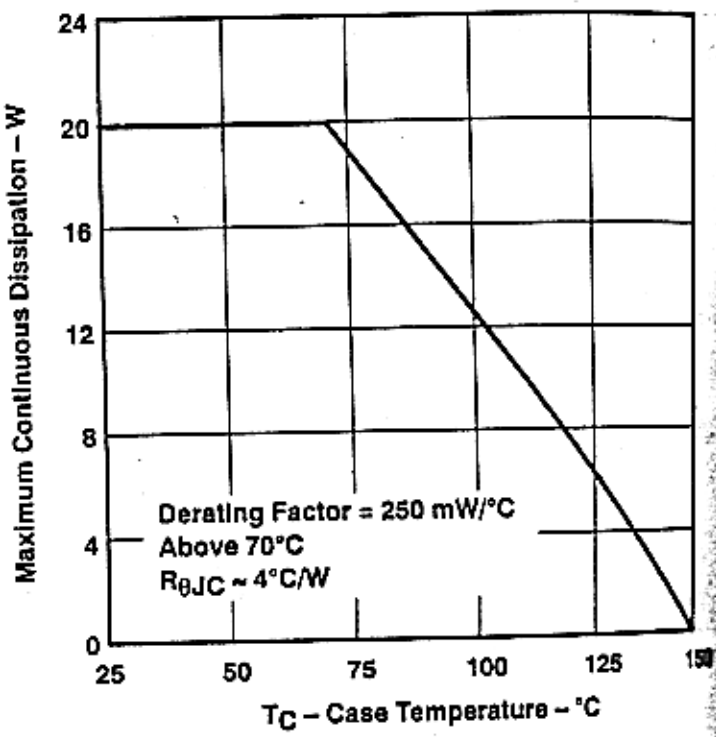


Figure 2

recommended operating conditions

	MIN	MAX	UNIT
Input-to-output voltage differential, $V_I - V_O$		125	V
Output current, I_O	15	700	mA
Operating virtual junction temperature, T_J	0	125	°C

electrical characteristics at $V_I - V_O = 25$ V, $I_O = 0.5$ A, $T_J = 0°C$ to 125°C (unless otherwise noted)

PARAMETER	TEST CONDITIONS†		MIN	TYP	MAX	UNIT
Input regulation‡	$V_I - V_O$ = 20 V to 125 V, P ≤ rated dissipation	T_J = 25°C		0.001	0.01	%/V
		T_J = 0°C to 125°C		0.004	0.02	
Ripple rejection	$\Delta V_{I(PP)}$ = 10 V, V_O = 10 V,	f = 120 Hz	66	76		dB
Output regulation	I_O = 15 mA to 700 mA, T_J = 25°C	V_O ≤ 5 V		7.5	25	mV
		V_O ≥ 5 V		0.15%	0.5%	
	I_O = 15 mA to 700 mA, P ≤ rated dissipation	V_O ≤ 5 V		20	70	mV
		V_O ≥ 5 V		0.3%	1.5%	
Output voltage change with temperature				0.4%		
Output voltage long-term drift	1000 hours at T_J = 125°C, $V_I - V_O$ = 125 V,	See Note 2		0.2%		
Output noise voltage	f = 10 Hz to 10 kHz, T_J = 25°C			0.003%		
Minimum output current to maintain regulation	$V_I - V_O$ = 125 V				15	mA
Peak output current	$V_I - V_O$ = 25 V, t = 1 ms			1100		mA
	$V_I - V_O$ = 15 V, t = 30 ms			715		
	$V_I - V_O$ = 25 V, t = 30 ms		700	900		
	$V_I - V_O$ = 125 V, t = 30 ms		100	250		
Adjustment-terminal current				83	110	µA
Change in adjustment-terminal current	$V_I - V_O$ = 15 V to 125 V, I_O = 15 mA to 700 mA, P ≤ rated dissipation			0.5	5	µA
Reference voltage (OUTPUT to ADJUSTMENT)	$V_I - V_O$ = 10 V to 125 V, I_O = 15 mA to 700 mA, P ≤ rated dissipation, See Note 3		1.2	1.27	1.3	V

† Pulse-testing techniques are used to maintain the junction temperature as close to the ambient temperature as possible. Thermal effects must be taken into account separately.

‡ Input regulation is expressed here as the percentage change in output voltage per 1-V change at the input.

NOTES: 2. Since long-term drift cannot be measured on the individual devices prior to shipment, this specification is not intended to be a guarantee or warranty. It is an engineering estimate of the average drift to be expected from lot to lot.

3. Due to the dropout voltage and output current limiting characteristics of this device, output current is limited to less than 700 mA at input-to-output voltage differentials of less than 25 V.

TYPICAL CHARACTERISTICS

OUTPUT CURRENT LIMIT
vs
INPUT-TO-OUTPUT VOLTAGE DIFFERENTIAL

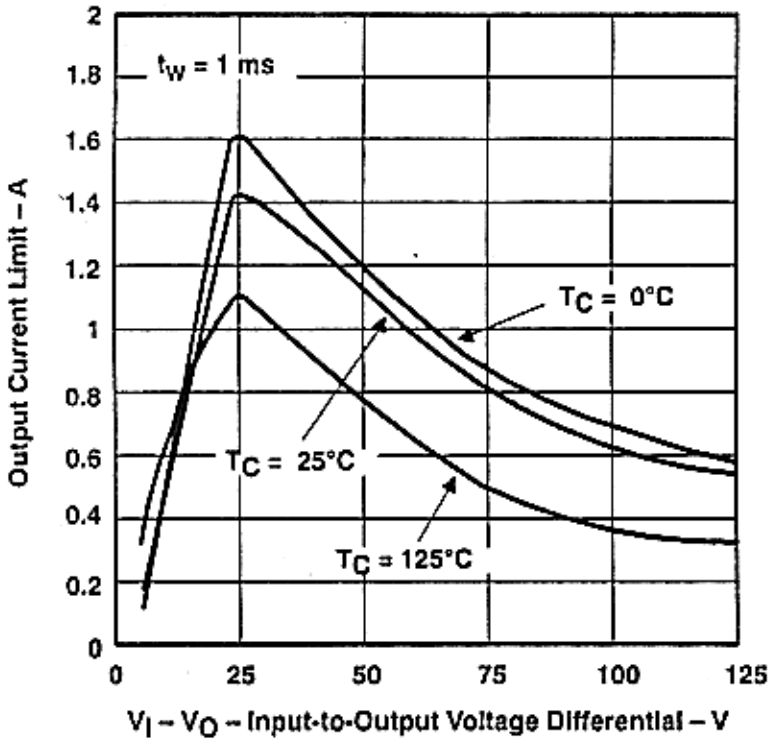


Figure 3

OUTPUT CURRENT LIMIT
vs
INPUT-TO-OUTPUT VOLTAGE DIFFERENTIAL

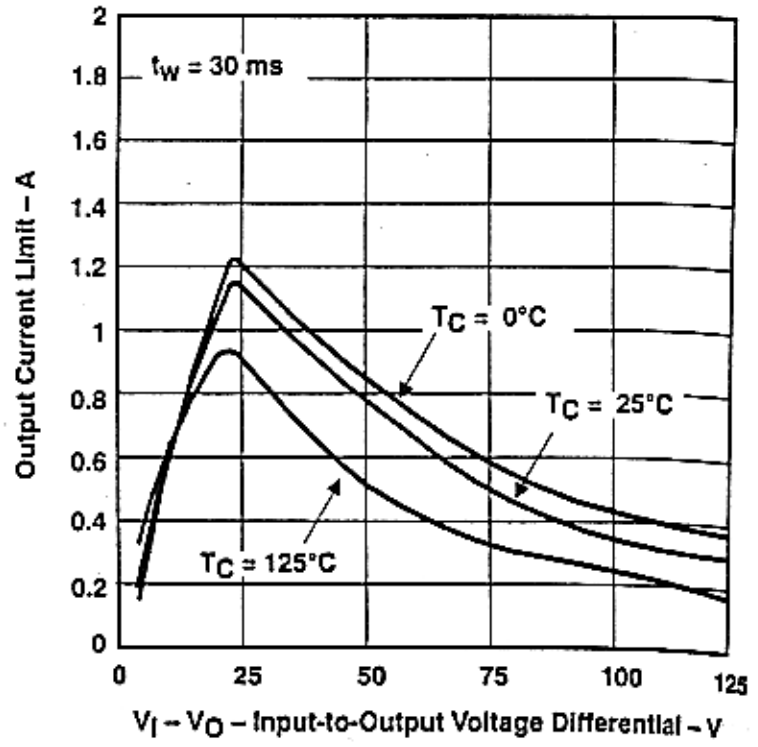


Figure 4

OUTPUT CURRENT LIMIT
vs
TIME

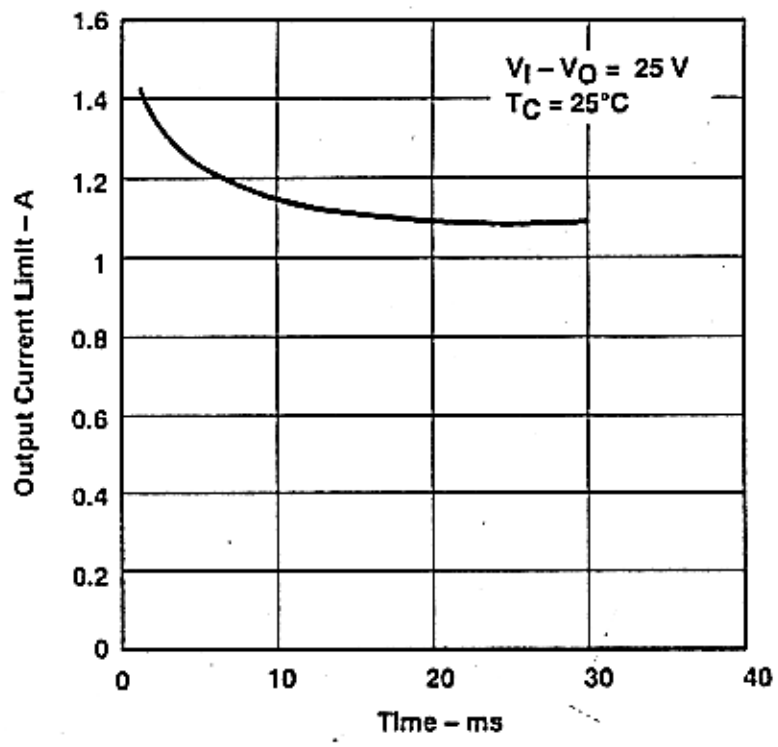


Figure 5

RIPPLE REJECTION
vs
OUTPUT VOLTAGE

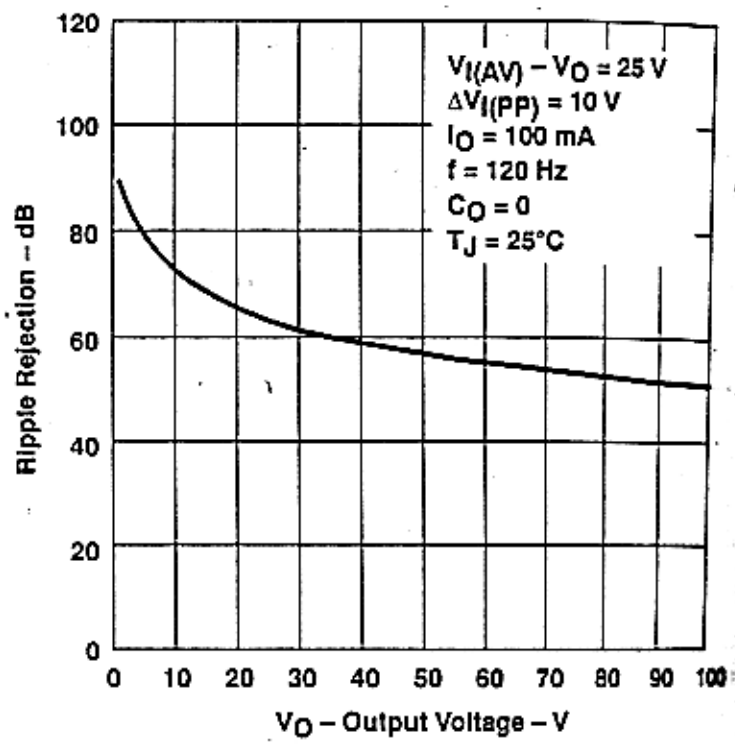


Figure 6

TYPICAL CHARACTERISTICS

RIPPLE REJECTION
vs
OUTPUT CURRENT

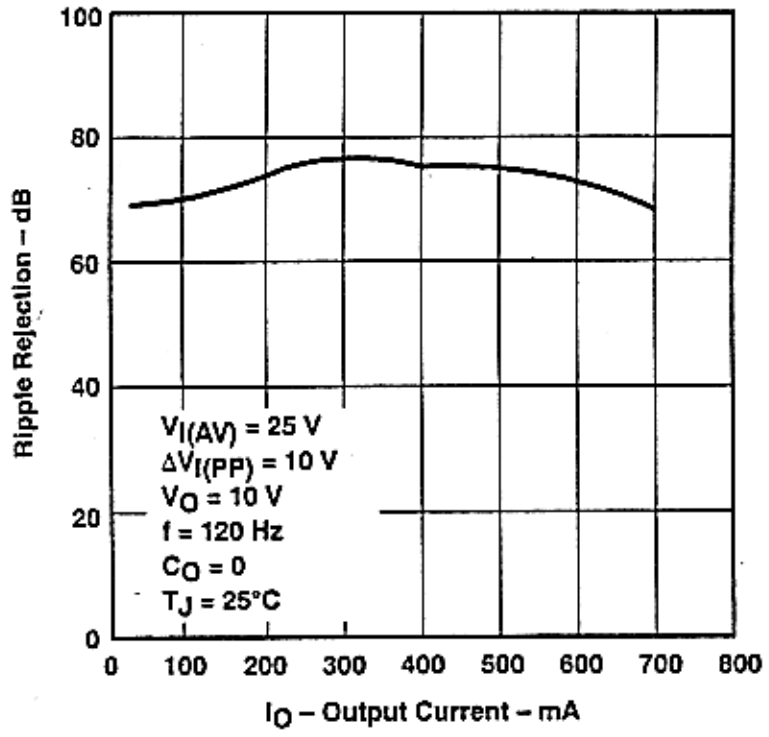


Figure 7

RIPPLE REJECTION
vs
FREQUENCY

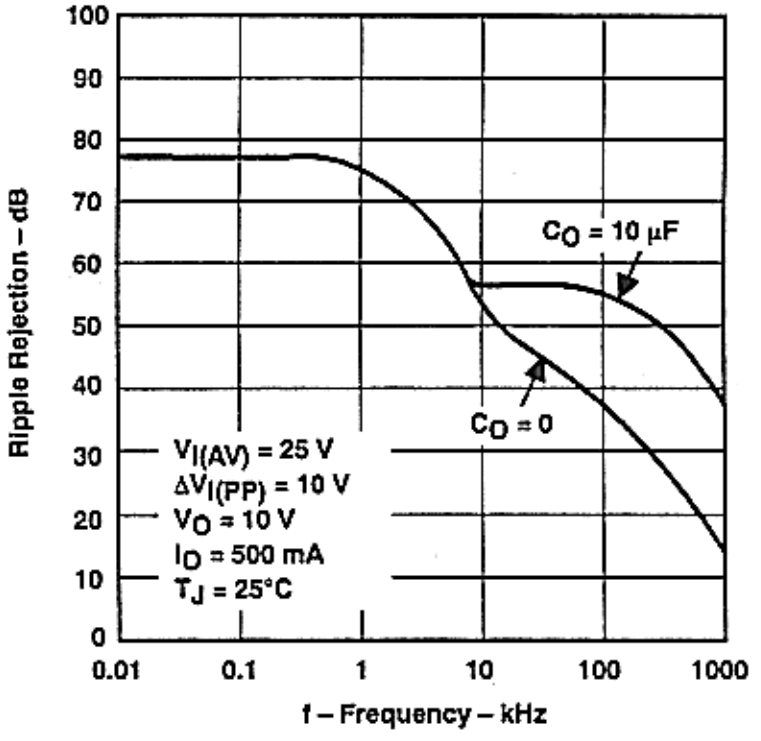


Figure 8

OUTPUT IMPEDANCE
vs
FREQUENCY

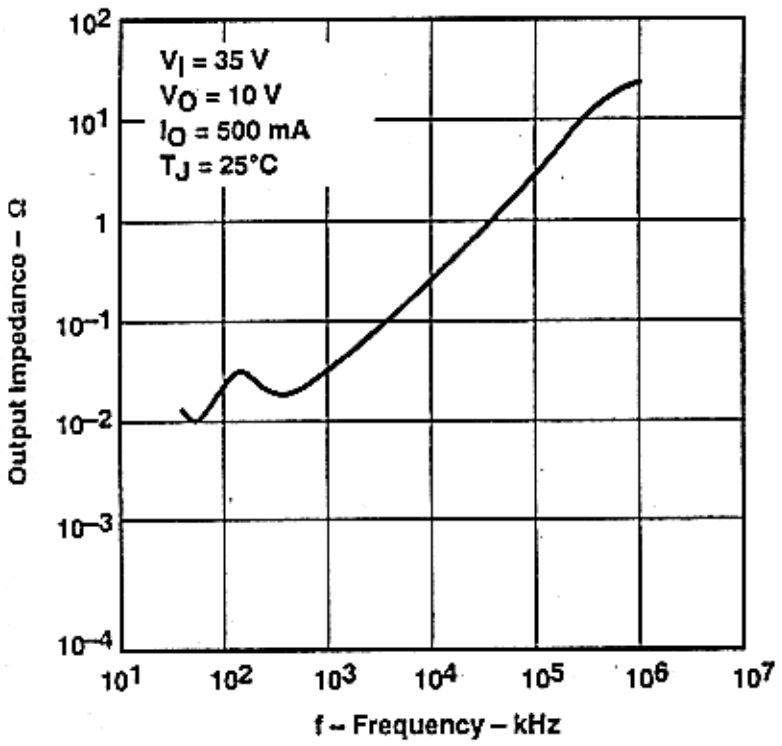


Figure 9

REFERENCE VOLTAGE
vs
VIRTUAL JUNCTION TEMPERATURE

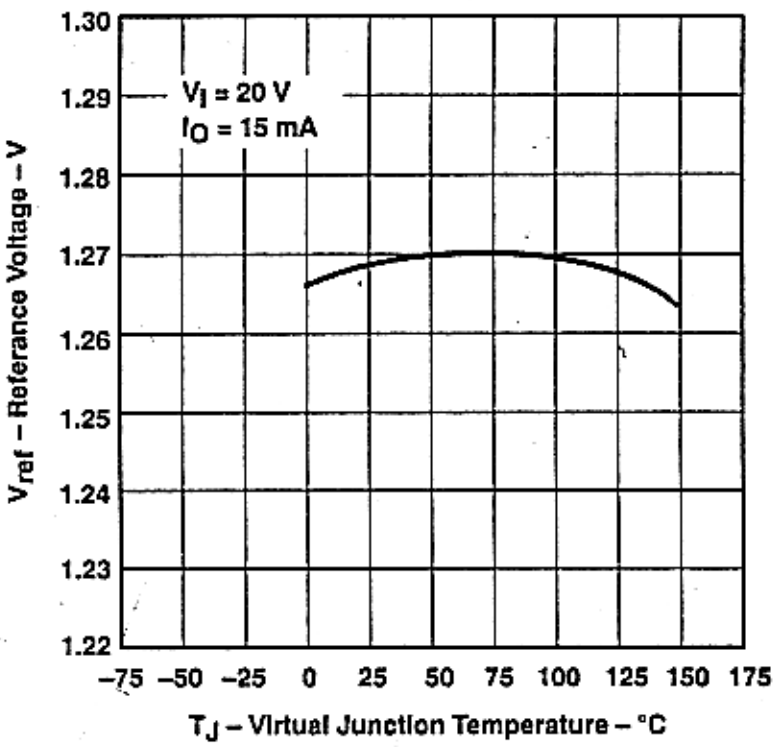


Figure 10

TYPICAL CHARACTERISTICS

ADJUSTMENT-TERMINAL CURRENT
vs
VIRTUAL JUNCTION TEMPERATURE

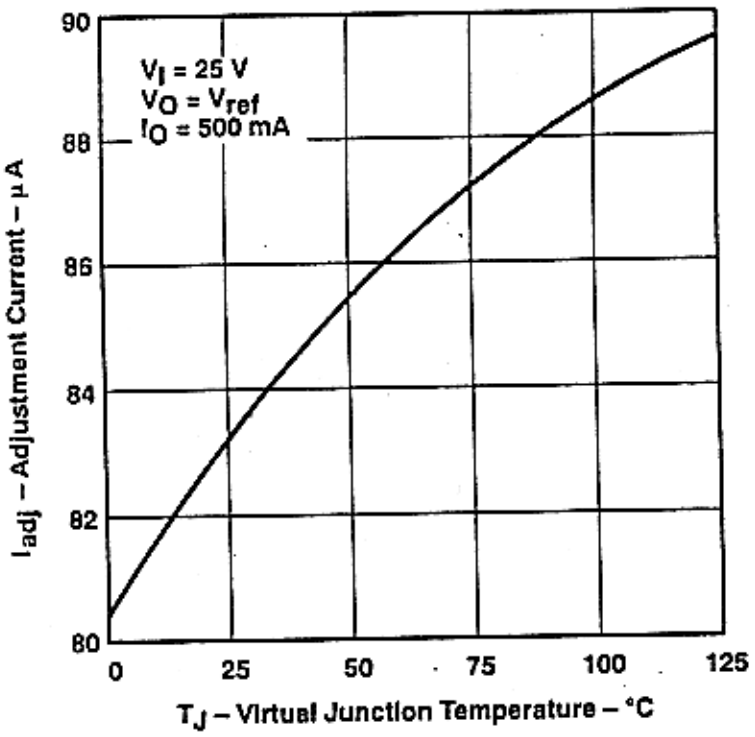


Figure 11

DROPOUT VOLTAGE
vs
VIRTUAL JUNCTION TEMPERATURE

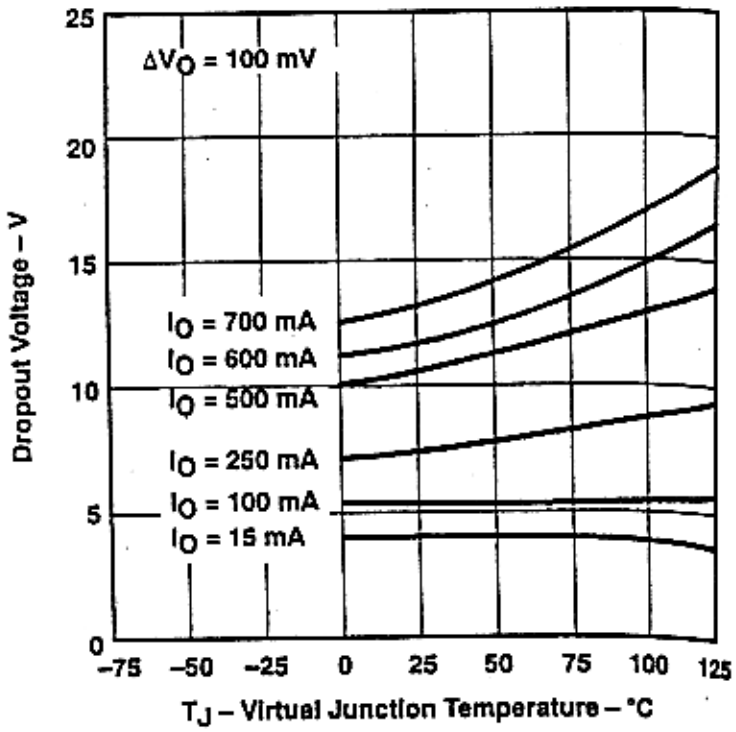


Figure 12

LOAD REGULATION
vs
VIRTUAL JUNCTION TEMPERATURE

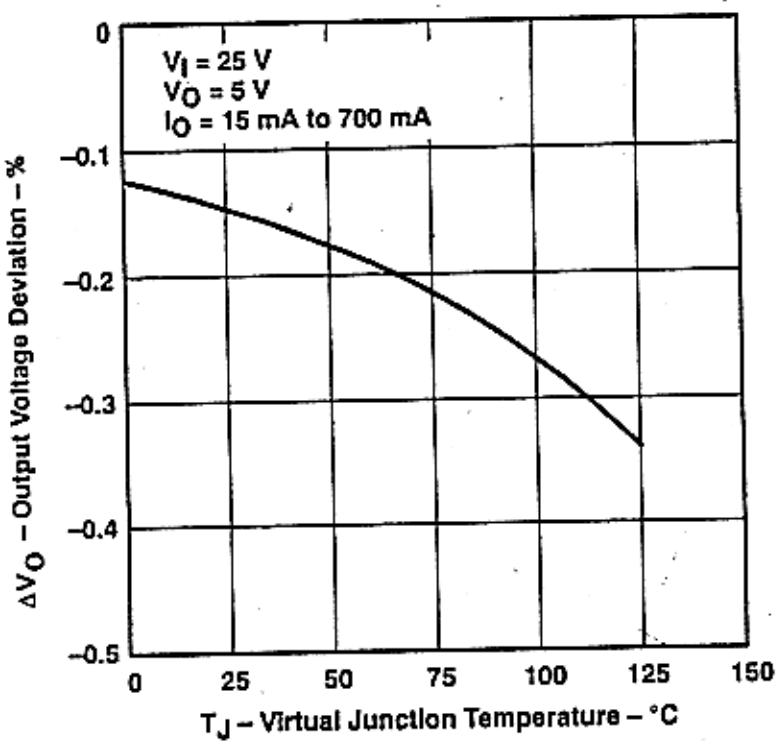


Figure 13

MINIMUM OUTPUT CURRENT
TO MAINTAIN REGULATION
vs
INPUT VOLTAGE

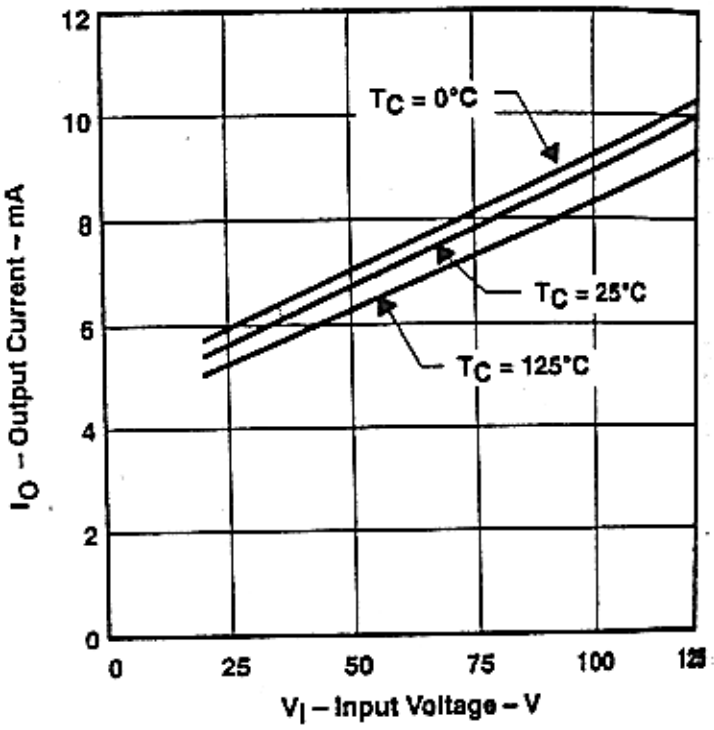


Figure 14

TYPICAL CHARACTERISTICS

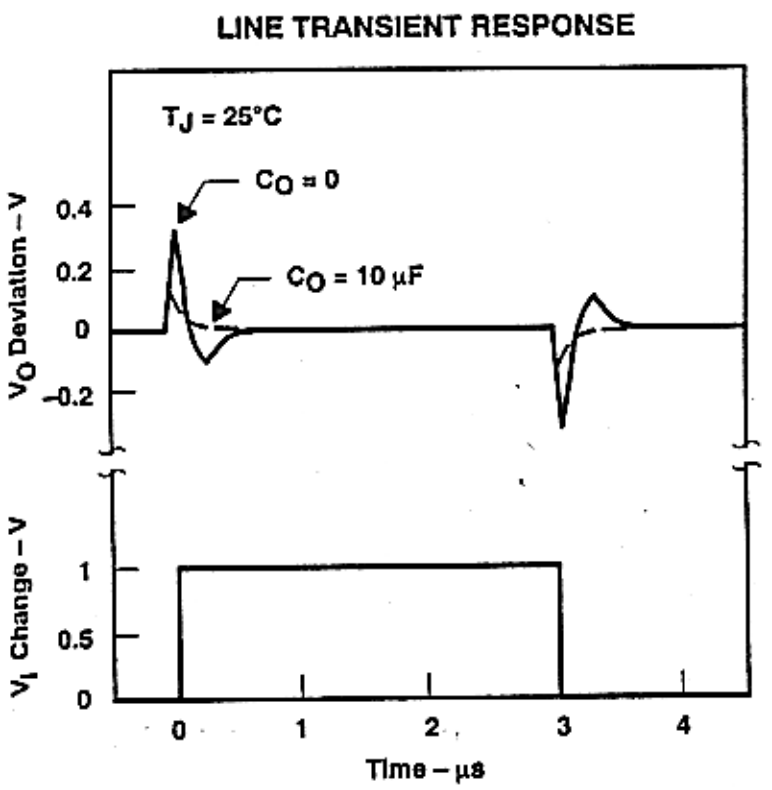


Figure 15

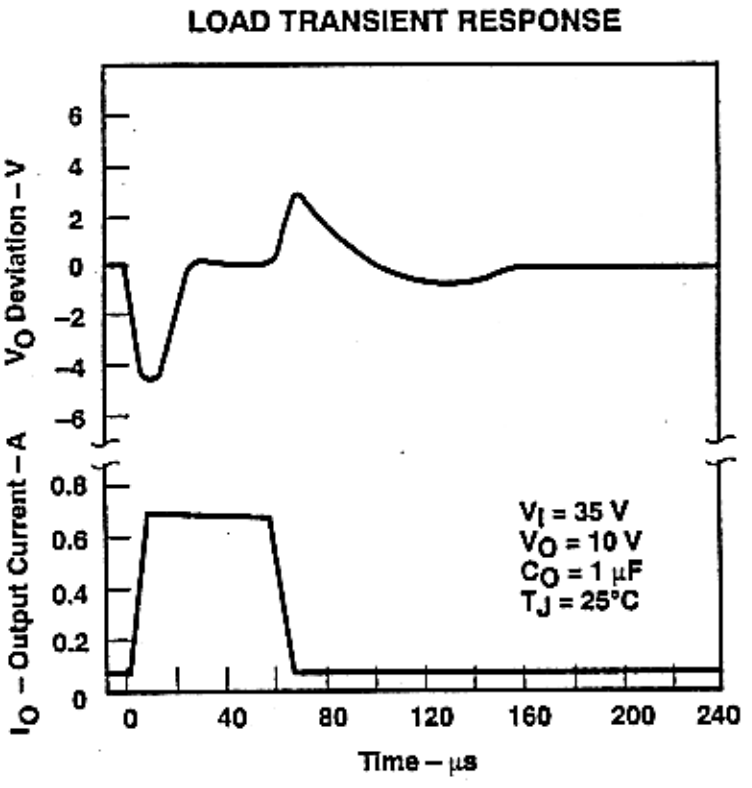


Figure 16

DESIGN CONSIDERATIONS

The internal reference (see functional block diagram) is used to generate 1.25 V nominal (V_{ref}) between the output and adjustment terminals. This voltage is developed across R1 and causes a constant current to flow through R1 and the programming resistor R2, giving an output voltage of:

$$V_O = V_{ref} (1 + R2/R1) + I_{adj} (R2)$$

or

$$V_O - V_{ref} (1 + R2/R1).$$

The TL783C was designed to minimize I_{adj} and maintain consistency over line and load variations, thereby minimizing the I_{adj} (R2) error term.

To maintain I_{adj} at a low level, all quiescent operating current is returned to the output terminal. This quiescent current must be sunk by the external load and is the minimum load current necessary to prevent the output from rising. The recommended R1 value of 82 Ω will provide a minimum load current of 15 mA. Larger values may be used if the input-to-output differential voltage is less than 125 V (see minimum operating current curve) or if the load will sink some portion of the minimum current.

bypass capacitors

The TL783C regulator is stable without bypass capacitors; however, any regulator will become unstable with certain values of output capacitance if an input capacitor is not used. Therefore, the use of input bypassing is recommended whenever the regulator is located more than four inches from the power-supply filter capacitor. A 1-µF tantalum or electrolytic capacitor is usually sufficient.

Adjustment-terminal capacitors are not recommended for use on the TL783C because they can seriously degrade load transient response as well as create a need for extra protection circuitry. Excellent ripple rejection is presently achieved without this added capacitor.

Due to the relatively low gain of the MOS output stage, output voltage dropout may occur under large load transient conditions. Addition of an output bypass capacitor will greatly enhance load transient response as well as prevent dropout. For most applications, it is recommended that an output bypass capacitor be used with a minimum value of:

$$C_O\ (\mu F) = 15/V_O$$

Larger values will provide proportionally better transient response characteristics.

protection circuitry

The TL783C regulator includes built-in protection circuits capable of guarding the device against most overload conditions encountered in normal operation. These protective features are current limiting, safe-operating-area protection, and thermal shutdown. These circuits are meant to protect the device under occasional fault conditions only. Continuous operation in the current limit or thermal shutdown mode is not recommended.

The internal protection circuits of the TL783C will protect the device up to maximum-rated V_I as long as certain precautions are taken. If V_I is instantaneously switched on, transients exceeding maximum input ratings may occur, which can destroy the regulator. These are usually caused by lead inductance and bypass capacitors causing a ringing voltage on the input. In addition, if rise times in excess of 10 V/ns are applied to the input, a parasitic n-p-n transistor in parallel with the DMOS output can be turned on causing the device to fail. If the device is operated over 50 V and the input is switched on rather than ramped on, a low-Q capacitor, such as tantalum or electrolytic should be used rather than ceramic, paper, or plastic bypass capacitors. A Q factor of 0.015 or greater will usually provide adequate damping to suppress ringing. Normally, no problems occur if the input voltage is allowed to ramp upward through the action of an ac line rectifier and filter network.

Similarly, if an instantaneous short circuit is applied to the outputs, both ringing and excessive fall times can result. A tantalum or electrolytic bypass capacitor is recommended to eliminate this problem. However, if a large output capacitor is used and the input is shorted, addition of a protection diode may be necessary to prevent capacitor discharge through the regulator. The amount of discharge current delivered is dependent on output voltage, size of capacitor, and fall time of V_I. A protective diode (see Figure 17) is required only for capacitance values greater than:

$$C_O\ (\mu F) = 3 \times 10^4/(V_O)^2.$$

Care should always be taken to prevent insertion of regulators into a socket with power on. Power should be turned off before removing or inserting regulators.

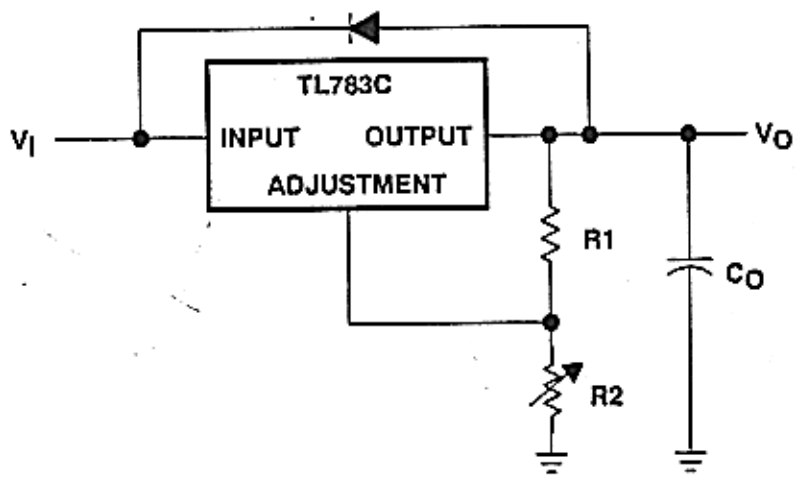


Figure 17. Regulator With Protective Diode

load regulation

The current set resistor (R1) should be located close to the regulator output terminal rather than near the load. This eliminates long line drops from being amplified through the action of R1 and R2 to degrade load regulation. To provide remote ground sensing, R2 should be near the load ground.

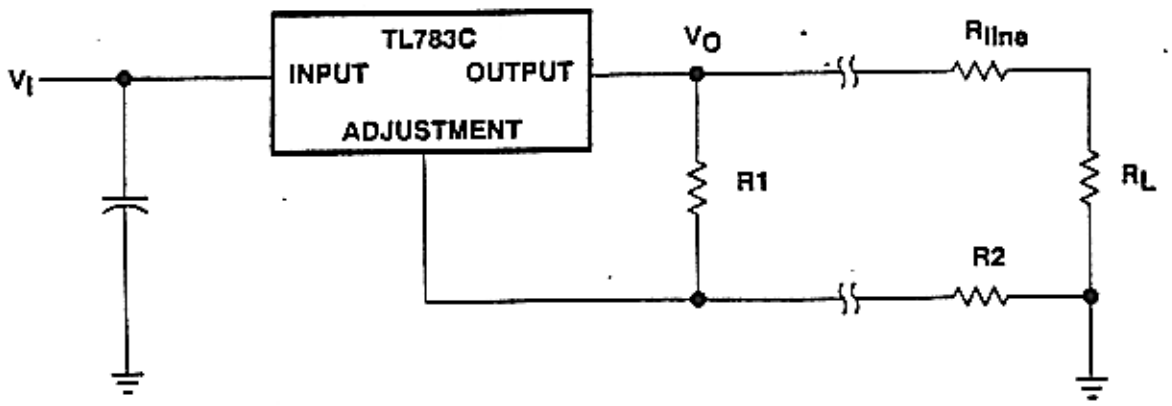
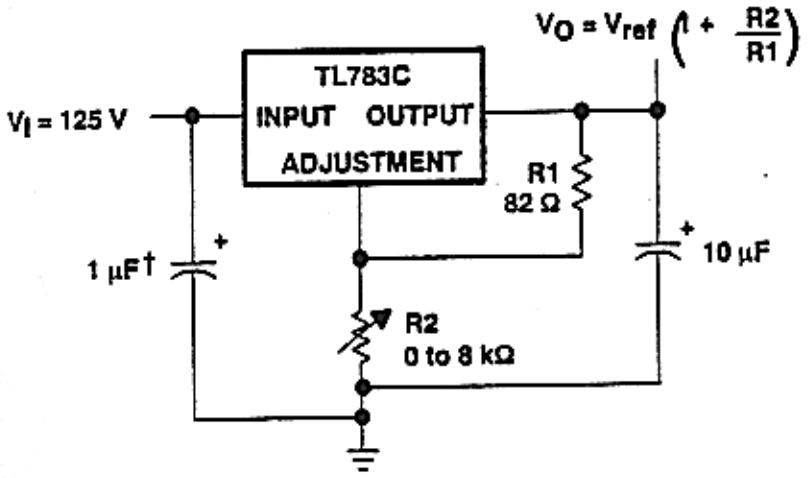


Figure 18. Regulator With Current-Set Resistor

APPLICATION INFORMATION



† Needed if device is more than 4 inches from filter capacitor

Figure 19. 1.25-V to 115-V Adjustable Regulator

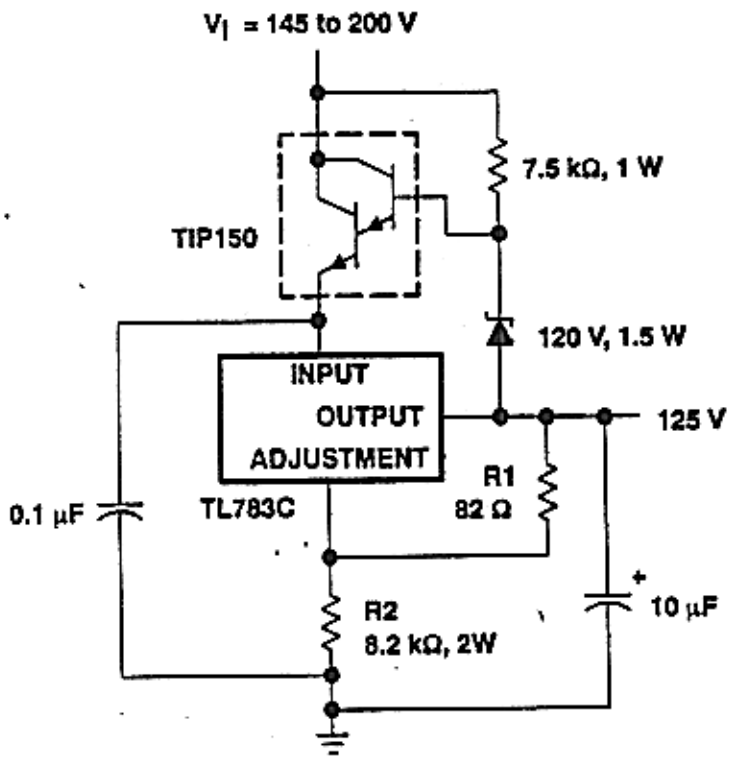


Figure 20. 125-V Short-Circuit-Protected Off-Line Regulator

APPLICATION INFORMATION

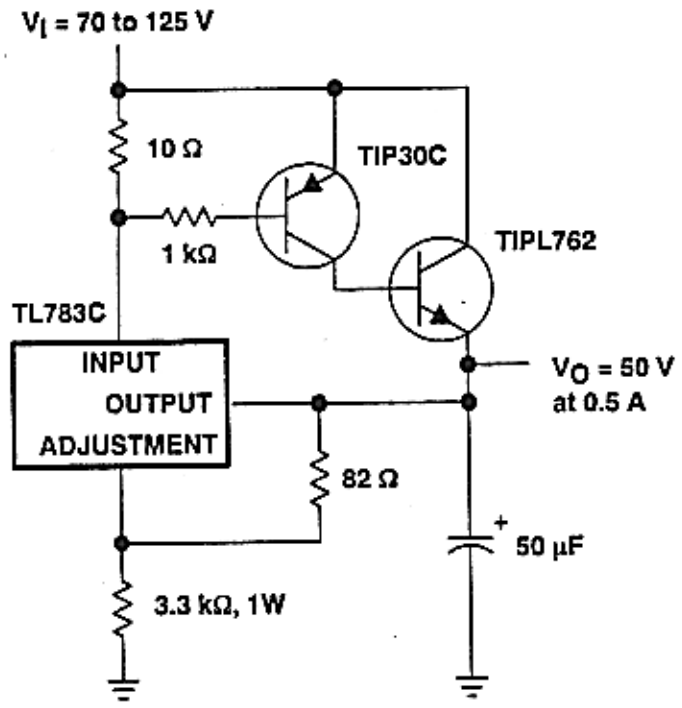


Figure 21. 50-V Regulator With Current Boost

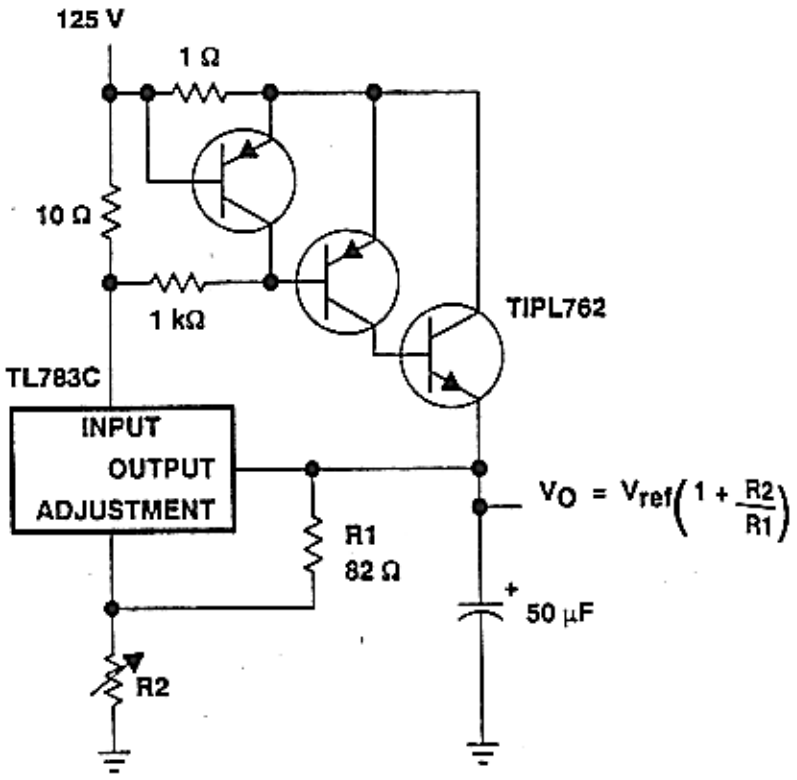


Figure 22. Adjustable Regulator With Current Boost and Current Limit

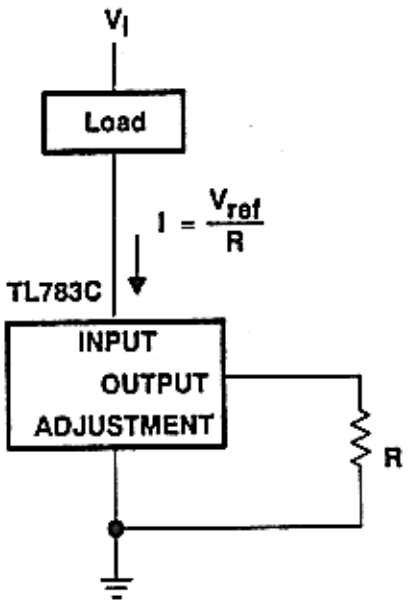


Figure 23. Current-Sinking Regulator

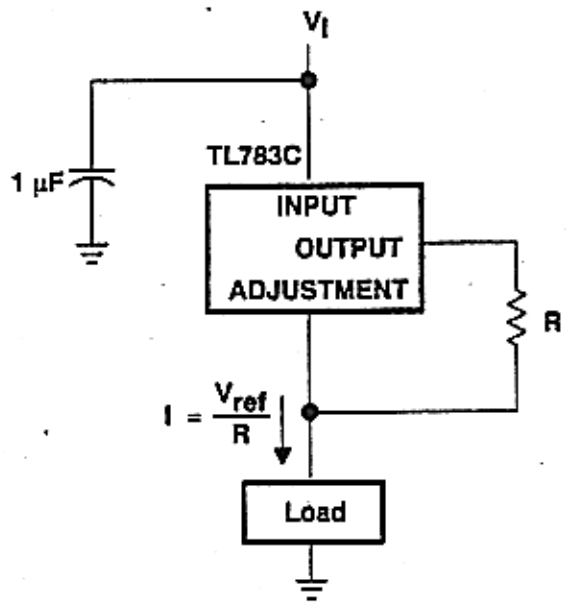


Figure 24. Current-Sourcing Regulator

APPLICATION INFORMATION

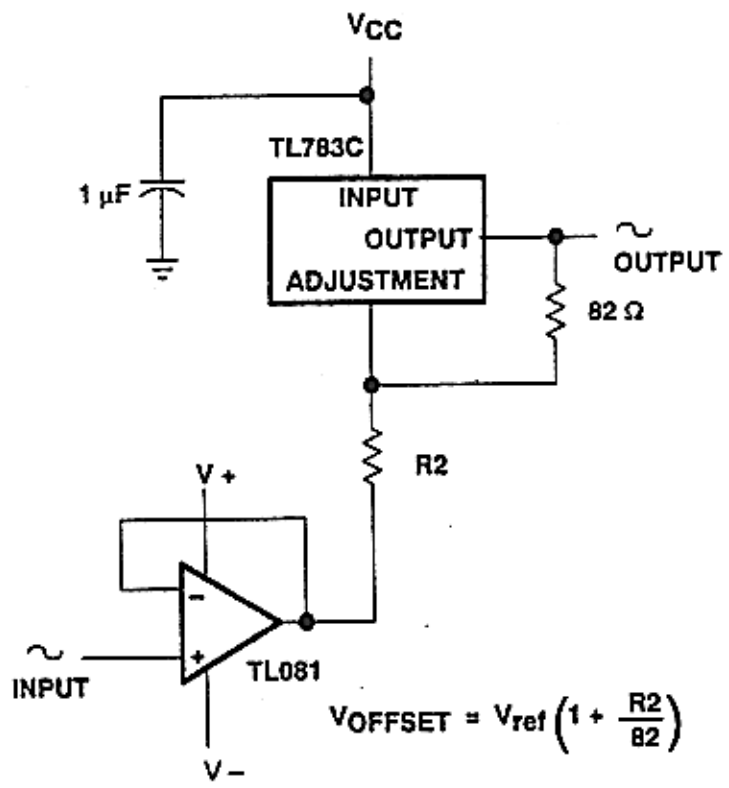


Figure 25. High-Voltage Unity-Gain Offset Amplifier

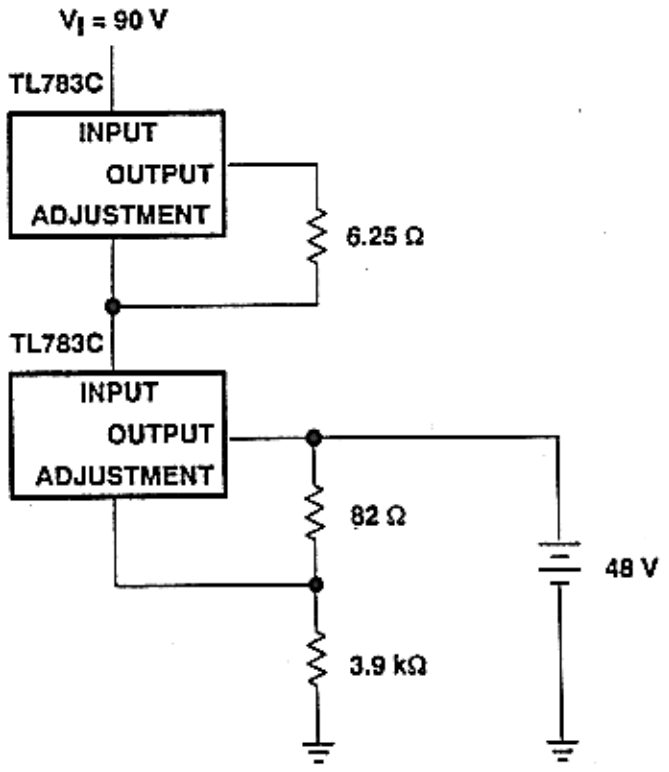


Figure 26. 48-V, 200-mA Float Charger